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THEORIES OF INDUSTRIAL ORGANIZATION AS EXPLANATIONS OF EXPERIMENTAL MARKET BEHAVIOR

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THEORIES OF INDUSTRIAL ORGANIZATION AS EXPLANATIONS OF EXPERIMENTAL MARKET BEHAVIOR

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The current professional interest in experimental economics seems to stem in part from a recently acquired ability of economists to explore subtle implications of institutional details for market performance. Advances in understanding the role of information in market models suggest the possibility that the contribution of institutions in affecting information patterns and resource allocation can be identified and assessed. Game theory has increasingly focused upon the structure of strategy spaces as dictated by special institutional structures. The discovery of the theoretical existence of decentralized incentive compatible processes for the provision of public goods allows one to speculate about the possibility of many different types of institutions which might solve the public goods and free rider problems. The continued growth and development of the field of law and economics has directed the theory toward the study of the relationship between legal technology and economic principles. Theoretical works on the nature of institutions and possible manifestations of their influence fill the journals.

Two problems accompany these academic exchanges and emphasize the need for data such as those generated by experimental methods. First, many different theories compete in providing predictions about the

consequences of institutional change. Such theories are generated from a variety of sources (e.g., small changes in the mathematical representation of an institution or of the individualistic behavioral response within an institutional environment can produce dramatic differences in predicted system behavior). Secondly, history is not always cooperative in creating circumstances which separate the predictions of theories. Two theories may have dramatically differing predictions within all future scenarios, but within all past conditions their predictions might be almost identical. Thus, historical circumstances do not always provide the opportunity for the relatively inaccurate models to be pruned from the tree of viable hypotheses.

These two problems are compounded by the sheer complexity of naturally occurring processes. Data are frequently buried. Many variables intervene. Furthermore, scholars of institutions and their consequences approach the subject with different preconceptions, experience, intuition, and academic disciplinary background and can accordingly be led to substantially different interpretations of such data that exist. Resolution of competing ideas can take years if not decades.

Experimental methods provide a source of shared experience for scholars who are developing and evaluating theories about complicated naturally occurring processes. While laboratory processes are simple in comparison to naturally occurring processes, they are real processes in the sense that real people participate for real and substantial profits and follow real rules in doing so. It is precisely because they are real that they are interesting. General theories must apply to special cases,

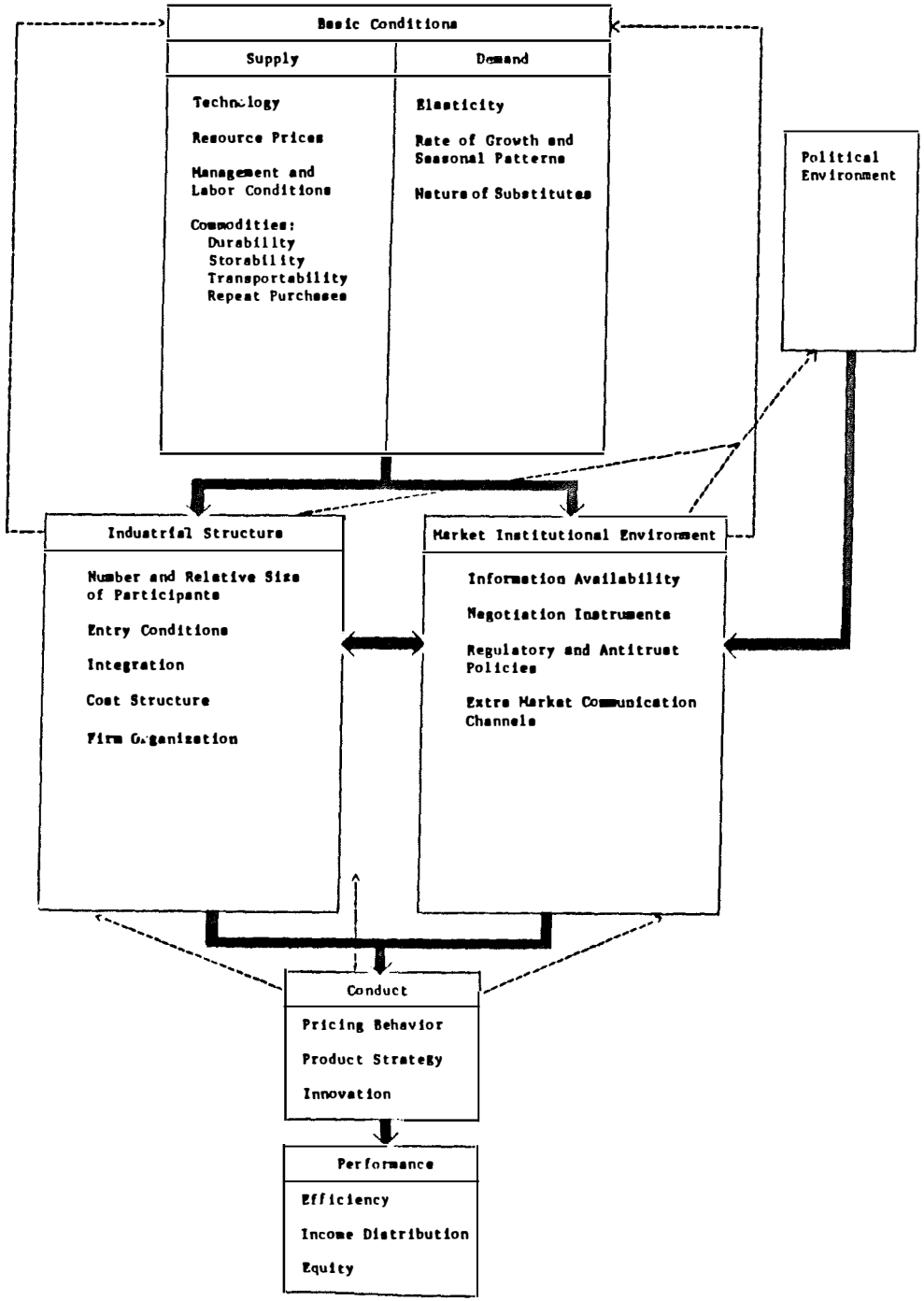
so models believed to be applicable to complicated naturally occurring processes should certainly be expected to help explain what occurs in simple, special-case laboratory markets. Theories which do not apply to the special cases are not general theories and thus cannot be advocated as such.[1]

Laboratory data become relevant to the extent that questions can be posed which make the study of special cases relevant. It may not be possible to learn about complicated processes directly by recreating them in a laboratory. General Motors, with all its size and institutional complexity, cannot be recreated many times for the convenience of those who wish to know what might have happened had one of its features been altered. Still, one might be able to learn something about competing models of a complicated process by gaining experience with their accuracy in simple cases. Circumstances in which models tend to be less reliable can be identified and, to the extent that the predictions of a model are accurate over a wide range of laboratory circumstances, one gains some confidence in their accuracy when applied to the more complicated, naturally occurring circumstances.

EXPERIMENTAL QUESTIONS RELATIVE TO INDUSTRIAL ORGANIZATION THEORY

The special cases reviewed here are those which have been of importance to industrial organization theorists. Figure 1 helps place them in a proper context by showing diagrammatically how the experimental questions are related to those of more traditional concern. The flow of the theory and the methodological perspective is consistent with that developed by Scherer (1971, pp. 3-7). The diagram is taken from Scherer with a few changes imposed to highlight the particular links which

FIGURE 1



experimentation has been used to explore. Variables which contribute to the nature of market demand costs, the psychological makeup of consumers, production technology as dictated by the physical properties of the commodity and engineering and management knowledge, resource availability, etc. are listed in the category of "basic conditions." Traditional theory provides an analysis of how the basic conditions tend to influence industrial structure (the number and size of firms, cost structures, degree of integration, etc.). This influence is represented by the dark arrow. The theory then continues to explore how industrial structure when combined with principles of economic behavior dictate conduct and performance.

Within this framework the special cases explored with laboratory tools can best be identified by adding another category drawing variables from both the traditional conduct category and the basic conditions category. These variables are those which characterize the market institutional environment. They are the rules and organizational structures which govern pricing and purchase decisions. In some cases they might be identified as aspects of managerial style and thus placed in the basic conditions category. In other cases they may be identified as aspects of the general marketing strategies of firms and thus be listed as part of conduct (e.g., price posting) Still, in other cases they are dictated by sources external to the industry such as governmental regulatory policies or as in the case of the securities industry by the policies of another industry (e.g., the stock exchanges) which specialize in providing marketing services. The particular market institutions which have been studied so far are listed in the next section.

Laboratory studies have focused upon how industrial structure and market institutions influence conduct defined in terms of price patterns and resource allocation and also how the two categories influence performance

defined in terms of income distribution and efficiency (the dark arrows). The link which has not yet been explored systematically is the influence of market structure on market institutional variables. No doubt in time this link will receive attention. Its importance is widely recognized but it does pose problems for experimental methods as discussed in the concluding section. Nevertheless the reader should be aware of the limited scope of existing results so they can be placed in a proper context.

Because laboratory studies focus upon particular links, they are special cases for the general theories which explain all the interactions, feedbacks (as represented by the dotted lines in the Figure) and influences among all three groups of variables: industrial structure, market institutions, and conduct. Within the general theory certain types of industrial structures are thought to directly influence market institutions (cartel organizations, for example, are thought to be more likely in markets with few firms) and then the market institutions once developed induce feedback effects which operate to change the industrial structure (e.g., firm size). Thus, the theory is applied to explain how both types of variables will evolve and, while evolving, will jointly influence market conduct. Experimental studies have tended to use this last link of the general theory as a guide to what to look for in the behavior of simple industries (relative to the naturally occurring industries). In most experimental work the basic conditions, the industrial structure, and the market institutions are all exogenously determined treatment variables. All are held constant while the resulting conduct is observed so the joint influences of industrial structure and market institutions on conduct and performance can be ascertained and understood in terms of the theories as applied to those circumstances.

THE SURVEY

Three broad generalizations seem to characterize observations drawn from laboratory environments. First, the standard mathematical models (with certain exceptions and qualifications) appear to apply with extraordinary accuracy. Basic principles of economics do seem to be operating. Secondly, there is a strong interaction between market institutions and industrial structure in determining market conduct and performance. The applicable model seems to shift with institutional changes. Third, successful collusions observed so far tend to involve the adoption of some type of institutional enforcement mechanism. Extramarket communications, for example, seem to be useful in establishing procedures and practices which can have an independent effect on prices. The success of attempts to collude seem to be related, in part, to success in establishing effective procedures.

The fact that interactions exist between industrial structure and market institutions poses an expositional problem. The number and variety of market institutions found in the world are staggering. When considered along with the different types of industrial structures, the possible combinations become large. The strategy of experimentalists for understanding them has been to identify the most prominent forms of market institutions and then to study the special variations. We have partitioned experiments into two general classes. The first class contains institutions and procedures in which there are no opportunities for decision makers to communicate other than through the ordinary activities of buying and selling. In the second class we explore the decisions made within institutions which allow "extramarket" communications. In these processes some participants (conspirators)

can make plans, commitments and/or agreements about the actions they will take in the market.

Five prominent forms of market institutions have been studied in the experimental literature: (a) auction markets, (b) posted bid (offer) markets, (c) negotiated price (telephone) markets, (d) price protection and advance notice policies. The fifth, sealed bid (offer) markets, will not be reviewed here.[2]

Actually, the listing of only five different types involves an oversimplification. Each of these types can be subdivided further into special types. Auction markets, for example, can be either English or Dutch according to whether the prices start low and are bid up by competition or start high and are reduced until some competitor accepts. English auctions can be "double oral" or "one aided." Markets differ according to whether or not the terms of contracts are public and the sequence in which bids, offers, and terms become known. The possibilities are so rich that it sometimes seems more appropriate to think in terms of a continuum rather than fixed classes. For example, posted price auctions look very similar to "sealed bid" auctions if sellers must post prices without the knowledge of other prices and without the ability to immediately "adjust" prices in light of the competition.

In addition to industrial structure and the market institutional environment, situations can differ according to the general information of participants. Agents may or may not be aware of the options or the payoffs of others. There may also be differences about the knowledge about others' knowledge. So the reader can see that relative to what one would like to know, the number of studies covered below is modest indeed.

THE ABSENCE OF EXTRAMARKET COMMUNICATION

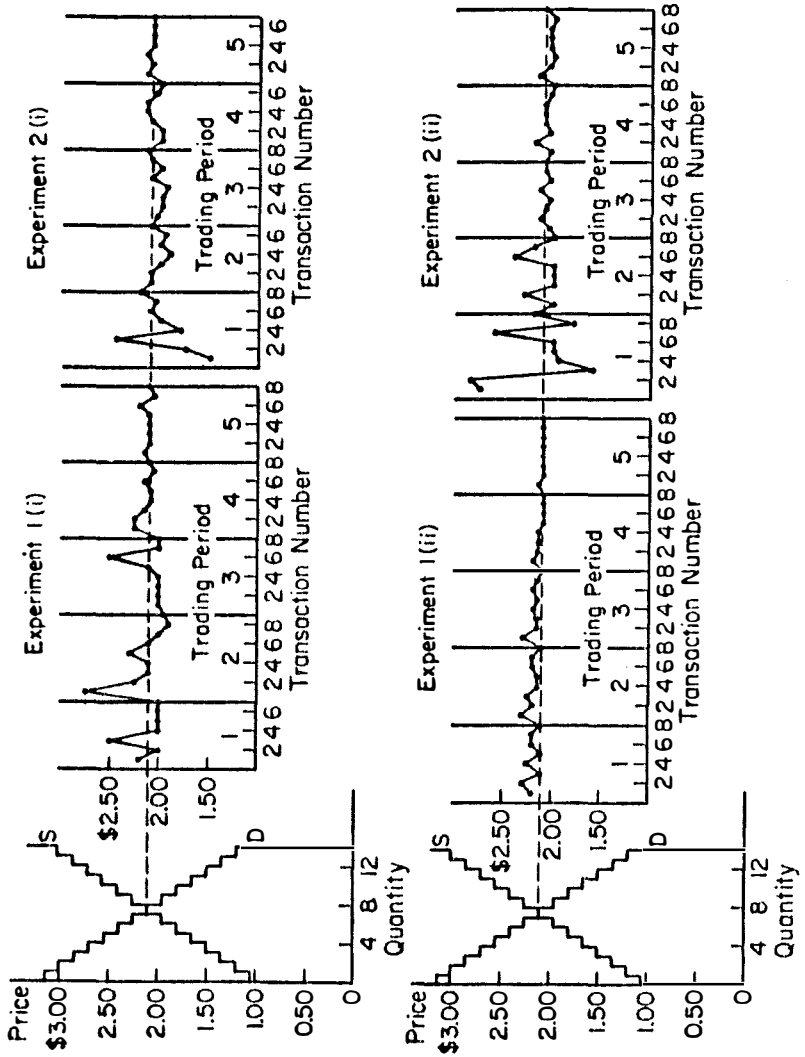
The behavior of the four different types of market institutions listed above will be reviewed. It seems fair to say that none of these different types of market institutions have been explored in sufficient detail to provide definitive statements about the influence of a wide variety of basic economic conditions such as demand elasticities and industrial structures. Nevertheless, the number of experimental conditions has been sufficiently rich to admit some comparisons and reasonable conjectures about what more systematic studies will reveal. The market studies reviewed in this section maintained strict control over communicatio In most cases participants were in the same room but communication was limited to the making of bids and offers, etc. as allowed by the technology of trading.

A. The Oral Auction Market

Oral auction markets are characterized by public bids (offers) to buy (sell) units and the freedom of any participant to accept terms which (s)he wishes. Several variants exist depending upon the length of time or circumstances under which a bid (offer) remains outstanding, whether the bid (offer) is made orally or logged through a computer, the roll of the specialist'a "book," etc.

The overwhelming result is that these markets converge to the competitive equilibrium. Figure 2 is typical of the time pattern of prices. Shown there is the price of every sale in the order in which it occurred. Each period represents a market day with a given demand and supply. The competitive equilibrium is $2 with a volume per period of eight contracts. As market days are replicated under identical conditions, prices tend to converge to the competitive equilibrium. Efficiency levels tend to

FIGURE 2



Source: Smith, Vernon L. "Bidding and Auctioning Institutions: Experimental Results." In Bidding and Auctioning for Procurement and Allocation, edited by Y. Amihud. New York: New York University Press, 1976a).

converge to near 100 percent. If a change in parameters had occurred, such as a shift in demand or in supply, the prices would have converged to the new equilibrium after two or three periods.

As long as the industrial structure has a few buyers and sellers, these convergence and efficiency properties appear to be independent of the basic economic conditions. Different shapes of demands and supplies as were systematically examined by Smith (1962, 1965, 1976a) yield no substantial differences. The variations explored covered various cases of demand elasticity and nonlinearity. In Smith (1965) a completely inelastic (in the relevant range) demand was used along with a fixed supply (greater than the quantity demanded). In all cases, after a few periods, the market performance was close to that predicted by the competitive model.

Other aspects of the basic economic conditions have been changed to allow for seasonality (Miller, Plott, Smith 1977; A. W. Williams 1979; Hoffman, Plott 1981), middlemen (Plott, Uhl 1981),[3] and other features having to do with the time dimension of a commodity life. In all cases the competitive model is an accurate predictor of market behavior. The model, when assets are involved, must be altered to accommodate rational expectations (Forsythe, Palfrey, Plott 1981) and inside information as to asset returns (Plott, Sunder 1980). Still the empirical generalization is that with the oral double auction the competitive model is an accurate predictor under all perturbations of the basic economic conditions even though only three or four sellers and/or buyers may be involved.

Basic economic conditions do seem to influence the direction of convergence to equilibrium and thus the distribution of income and profit. The path to equilibrium seems to be from above (below) if consumer's (producer's) surplus is greater than producer's (consumer's)

surplus. Thus, one might expect that markets with relatively steep demands and reasonably flat supplies record somewhat elevated profits for the sellers relative to the competitive equilibrium. These profits would accrue at disequilibrium trades and so the phenomenon would also be accompanied by falling prices. If the industry has been characterized by unanticipated demand or supply shifts, prices and profits can be affected. Adjustment to new equilibriums takes time and profits or losses can certainly reflect disequilibrium trades. To date only one study has attempted to characterize the dynamic adjustment path (Smith 1965) and the conclusions from this are clouded (Nelson 1980). No good theory of adjustment exists and experimental studies have not yet explored the influence of basic economic conditions on adjustment paths sufficiently to provide any further generalizations.

Changes in the market institutions are known to influence price and profit patterns. Double auctions conducted by computer can affect the speed of convergence especially with inexperienced participants (A. W. Williams 1980). For single unit auctions differences are exhibited between the Dutch auction, English auction, and second price auction. Theoretically (Nash bidding hypothesis) the English and second price auction should yield the same revenue while the Dutch, assuming some risk aversion, should yield more than both. The fact is, however, that the Dutch auction yields amounts less than or equal to the other two (Coppinger, Smith and Titus 1980). The Dutch auction also yielded less revenue than the first price auction which is theoretically similar.

The most dramatic difference within the class of oral auction institutions occurs with the one sided auctions. The approach to equilibrium is from above (below) if the auction is a one-sided (offer) auction. That is, if buyers (sellers) can bid (offer) while sellers

(buyers) must accept or reject without making counter offers (bids), then the approach is from above (below). The distribution of income is against the side which articulates the terms (Smith 1964; Plott, Smith 1978). Exactly why this occurs is not known but notice the implication. Sellers who face an oral auction institution would prefer that the buyers bid. To the extent sellers can organize themselves to compete by accepting favorable bids and not making counter offers, the approach to equilibrium and thus profits will be influenced in their favor. Similarly, markets organized as oral offer markets may have some use as tools to counteract "unjustified market power" of sellers. It is important to note, however, that the nonmonopolized one sided oral auctions examined to date have all been near 100 percent efficient. The institution affects only the distribution of income.

The importance of industrial structure has not been systematically explored. For one reason the results under the oral auction institutions appear to be almost independent of industrial structure. Experiments with three and four sellers converge with regularity to the competitive equilibrium. If influences from industrial structure exist, they are not so pronounced as to be clearly detectable in existing data.

Monopoly is the exception to the lack of attention. In a remarkable series of experiments, Smith (1981) demonstrated the importance of industrial structure. Monopolies can definitely cause prices to diverge from the competitive equilibrium. However, the monopoly model itself did not do so well. There is a strong tendency for prices to erode away from the monopoly equilibrium price. In some cases the price actually approached the competitive equilibrium.

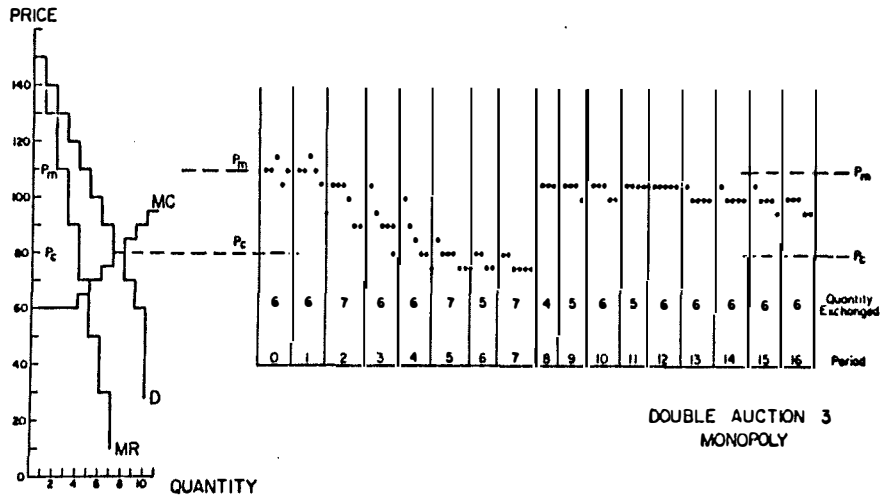
The number of observations so far is too small to determine which model is the best to modify. Figure 3 reproduces the time series from a particularly interesting experiment which demonstrates the difficulty with making any general statement about the comparative accuracy of the models. Prices start high near the monopoly price, erode to the competitive equilibrium, return to the high levels, and begin to erode again. This interesting behavior seems to be attributable to the buyers who have considerable power under this institution. By some process of "counterspeculation" they tend to withhold purchases and force prices down when facing a monopolist in this arena. Exactly what coordinates this action is unknown (these buyers cannot communicate except through bids and offers) but, as will be shown below, certain institutions seem to prevent it and therefore help the monopolist.

B. Negotiated Prices

Negotiated price market institutions are those within which the terms of trade are privately negotiated with each transaction. Experimentally these conditions have been implemented through a telephone system where buyers and sellers, each located in a private office, negotiate privately by telephone. Buyers can call sellers and vice versa and discuss terms and/or agree on a contract price. Contact among buyers or among sellers is prevented. Consequently in these markets information about prices is not public. Buyers can shop among sellers and shopping costs are low (in some experiments advertising is permitted) but shopping and negotiating are the only sources of information.

The first experiments of this kind were done by Hong and Plott (1981). The distribution of prices from one such experiment is shown in Figure 4. As can be seen, the system begins with a high

FIGURE 3



Source: Vernon L. Smith. "An Empirical Study of Decentralized Institutions of Monopoly Restraint." In Essays in Contemporary Fields of Economics, edited by George Horwich and James Quirk. West Lafayette, Indiana: Purdue University Press, forthcoming spring 1981.

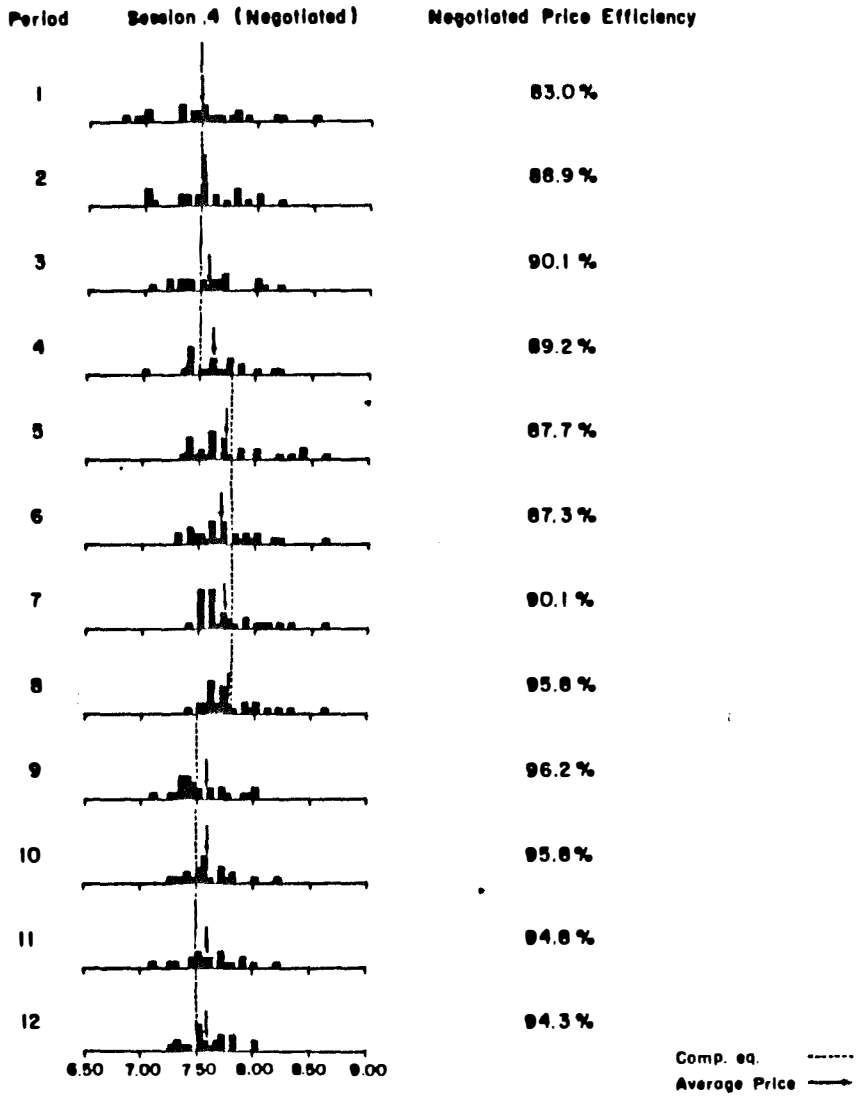


FIGURE 4

variance. Evidently some buyers are just better negotiators than others but the source of this (dis)advantage, whether they shop more (less), make more (less) credible promises or threats, etc., is unknown.

With time the variance shrinks. The mean price approaches the competitive equilibrium. When demand shifts (periods 5 and 9) the prices approach the new equilibrium. Efficiency in these markets is high as is shown on the figure.

Only two different industrial structures have been explored within this market institution. The Hong and Plott study had eleven buyers of about equal size. The twenty-two sellers, however, ranged from very large (the five largest firms had 60 percent of the market) to very small sellers, some of which should not exist according to the competitive model because their costs were above the competitive equilibrium price. As is implicit in the price time series, the competitive model is reasonably accurate. The exceptions were the marginal sellers who were able to exist by selling at prices above the competitive equilibrium prices to (evidently) poorly informed buyers or those who did not care to shop.

The second study is by Plott (1981) who studied telephone markets with two large sellers (35 percent each) and two small sellers (15 percent each). Sellers in the experiment even had accurate knowledge of the market demand functions. The average prices as shown for all periods on Figure 5 are typical of the general results. Similar to the Hong and Plott results prices start with a high variance. With time, variance is reduced and the competitive equilibrium is approached.

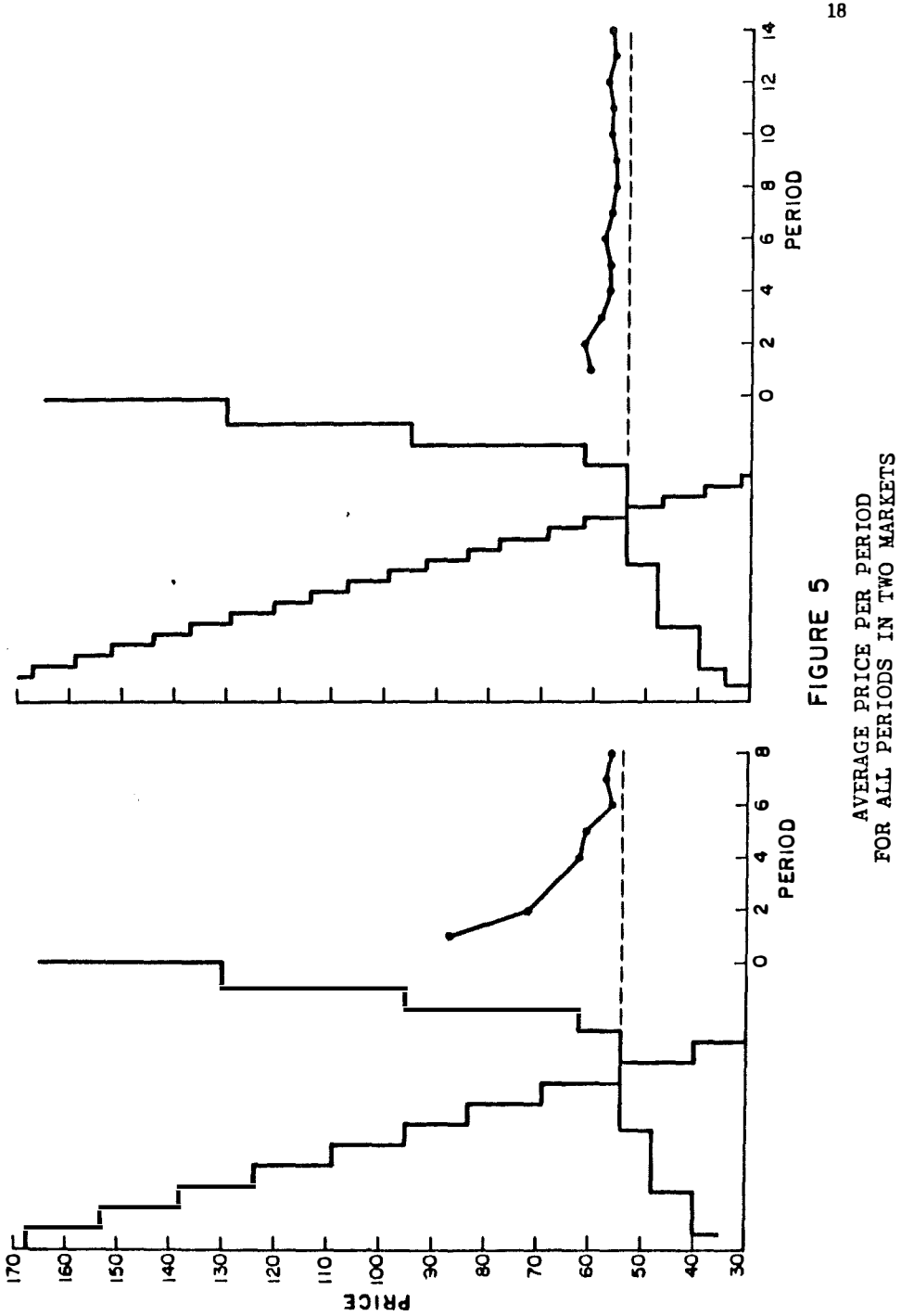


FIGURE 5
AVERAGE PRICE PER PERIOD
FOR ALL PERIODS IN TWO MARKETS

C. Posted Prices

The posted price institution has received more scholarly attention than any other. Frequently, however, those conducting the research did not view themselves as engaged in a comparative institutional analysis. The original duopoly experiments of Fouraker and Siegel (1963) utilized the posted price institution. Almost all "market games" and "prisoner's dilemma" experiments can be interpreted as having posted prices. However, before reviewing duopoly perhaps it is best to review the two polar cases of "many" sellers and one seller.

Two generalizations seem possible at this time. The most significant generalization is that posted offer (bid) markets tend to have higher (lower) prices than do oral double auction markets. Secondly, efficiency tends to be lower under the posted price institutions than under the oral double auctions.

These tendencies were first observable in experiments run by F. Williams (1973) who incorrectly thought they were due to the fact that his traders could buy or sell more than one unit. The results of two of his experiments are shown in Figure 6. These show the cumulative volume of trades at each price (e.g., the curve indicates the number of trades at price P or above). Prices at first are removed from equilibrium but with time they drift to close to the equilibrium. Whether or not posted price markets ever stabilize at the competitive equilibrium is an open question. Certainly this does not occur within the number of periods characteristically necessary for oral auctions.

The Willisms' results were replicated by Plott and Smith (1978) who also demonstrated that the market institution and not multiple units is the cause. The possible importance of basic market conditions and industrial structure is investigated in Hoffman and Plott (1981) and

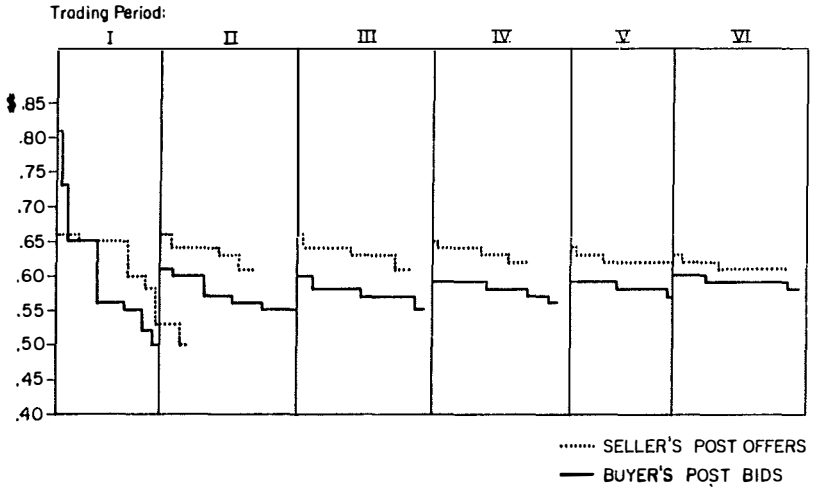


FIGURE 6

WILLIAMS' RESULTS:

CUMULATIVE DISTRIBUTION OF TRADES WITH MULTIUNIT INCENTIVES*

The figure represents for each price p, the volume of trades which took place at a price $p \geq p^*$.

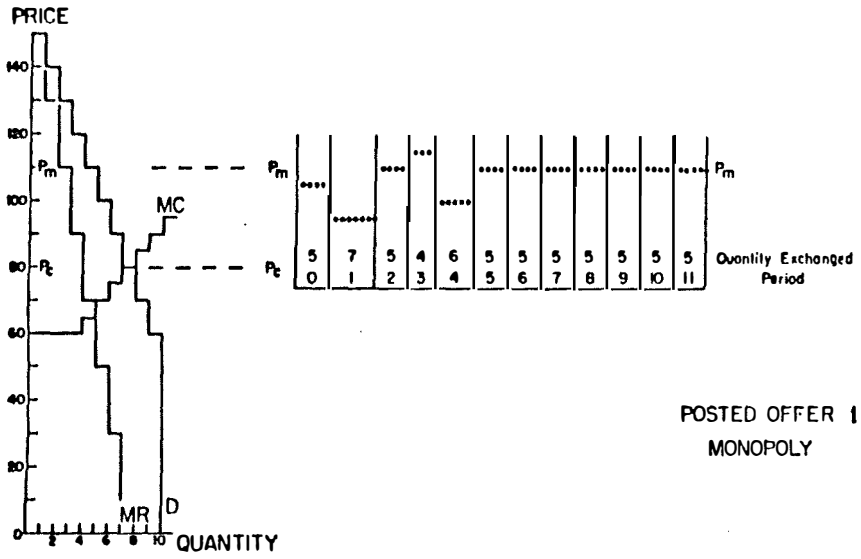
Source: Charles R. Plott and Vernon L. Smith. "An Experimental Examination of Two Exchange Institutions." Review of Economic Studies 45 (February 1978):135

Hong and Plott (1977). In the former posted prices in markets with storage and speculation were studied. In the latter study thirty-three sellers were involved as opposed to the four in all other experiments. The two generalizations were observed to hold in all cases.

The Plott and Smith experiments and many subsequent experiments used people as buyers who could withhold purchases and play favorites to encourage low prices. The Williams experiment on the other hand utilized a computer in some sessions to simulate demanders according to the following strategy: first, purchase from the low priced seller all s(he) wished to sell and then move to the next low priced seller, continuing until excess demand does not exist. One of the principal discoveries of Plott and Smith was that their demanders behaved passively (or purely competitively) almost exactly like the Williams computer. This suggests that one of the major features of the posted institution is that the "power" of the nonposting side is somehow eliminated. From an intuitive point of view one can see that when facing posted prices, abstinence is less likely to be met by more favorable terms because once the price is posted it cannot be changed until after the buying period is over. "Counterspeculation" as present in one sided oral auctions is absent under posted prices.

Results of monopoly operating with a posted price are reported in Smith (1981). The importance of industrial structure and the interaction between structure and market institutions is seen by studying Figure 7 and comparing the results with those from other monopoly experiments, e.g., Figure 3. As can be seen, under the posted offer institutions monopoly behaves exactly as monopoly theory asserts. The monopolist adjusts prices to measure demand (the measurements are accurate because

FIGURE 7



Source: Vernon L. Smith. "An Empirical Study of Decentralized Institutions of Monopoly Restraint." In Essays in Contemporary Fields of Economics, edited by George Horwich and James Quirk. West Lafayette, Indiana: Purdue University Press, forthcoming, 1981.

of buyer behavior), ascertains the profit maximizing price, sets price at that level, and leaves it there. Buyers facing fixed prices reveal their demand function. Compared to the oral auction the posted offer market is mechanical.

The posted price institution has been used in almost all oligopoly experiments. The practice was (perhaps inadvertently) introduced by Fouraker and Siegel (1963). Each subject seller was given a profit table indicating profits as a function of own price and the competitor's price. The sellers during a period chose only a single price and the decision was irrevocable. Since a fixed profit function was provided, the procedures implicitly assume that buyers do not speculate and behave "passively" as under the posted price institution.

For the most part the basic market conditions were for homogenous commodities. Use of a profit table implies that the market demand function is known with certainty (unlike experiments discussed above). Prices above a competitor's price result in no sales and a small loss. Cost conditions were such that zero profits were earned at the competitive equilibrium and price levels below this involved a loss for all agents (a feature added by J. L. Murphy, referenced below). The economic interpretation would be one of no rents, and one consequence of this lack of "producer surplus" is that prices must necessarily approach the competitive equilibrium from "above." The major treatment variable in the basic economic conditions category was the symmetry of the payoff functions, thus implying something about similarity of costs (for the homogenous product case the interpretation would be that all costs are constant at zero). Market structures were primarily duopolies but triopolies were also studied.

The primarily institutional variable aside from the posted price, involved the amount of knowledge available to agents. Under the Fouraker and Siegel complete information condition, the public information was that all agents knew all past choice and profits of all other agents. In the incomplete information condition, the public information was that profits were unknown and an agent only knew whether his price was higher or lower than competitors.

If one uses as the market price the lowest price in the market (the price at which all trades take place) then Fouraker and Siegel discovered a strong tendency for prices to converge toward the competitive equilibrium. By the fourteenth period the competitive equilibrium price prevailed in eleven of seventeen markets and was at the neighboring price (the price nearest the competitive equilibrium for five more) in the case of incomplete information. The complete information case yielded convergence in the direction of the competitive equilibrium but prices were higher at this fourteenth period stage.

In a study by Murphy (1966) a similar decay process was observed in duopolies operating under the incomplete information condition. In general, however, he found the decay process to be slower with prices tending to hang somewhat higher above the competitive equilibrium than did Fouraker and Siegel (attributed by Murphy to the threat of possible loss which was possible in his payoff tables). In addition, Murphy observed five duopolies (out of seventeen) which were able to coordinate price increases which converged to the joint maximum and a sixth was near the joint maximum. Convergence to the joint maximum was not monotone. Instead, almost all of the duopolies experienced the competitive decay at first and then after several periods, prices began to drift upwards for those that ultimately

converged to the joint maximum (the Murphy experiments were twenty-four periods as opposed to fourteen for Fouraker and Siegel).

Presumably this "cooperative" phenomenon in duopolists operating under these conditions is facilitated by many trials and experience. The latter was explored extensively by Stoecker (1980) within the same parametric and institutional environment as Murphy only with complete information. Rather than many periods of a single market Stoecker allowed individuals to obtain experience from many markets of ten periods each. Thirty-seven out of fifty duopoly markets managed substantial cooperation (at or near the joint maximum). None of the remainder exhibited the property of the oral double auction of monotone convergence to the competitive equilibrium. Jumps of price were common.

In Fouraker and Siegel and in Stoecker both of the basic economic conditions of profit function symmetry (Stoecker studied two different types of asymmetry) and the market structure (two, three, and five agent markets) were examined. Symmetry results in high market prices. Presumably this is because coordination is easier--the actions of the other can be more clearly understood and there can be no disagreement over the joint strategies. If both are to charge the same price, a unique Pareto optimum exists. An increase in the number of firms almost always results in a convergence of price to levels near the competitive equilibrium. However, a slight upward bias relative to the competitive equilibrium even when the number of firms is "large," appears to be part of the general properties of the posted price institution.

The work of Friedman (1963, 1969, 1970), Hoggatt (1959, 1967)

and Dolbear, et al. (1968) has extended the posted price research initiated by Fouraker and Siegel in several directions. In these markets, products are no longer homogeneous in the sense that higher prices than a competitor's result in zero sales and a loss. As a result of this innovation the information conditions can be altered. Perfect information means that all profit functions and past price choices are known. Incomplete information means that all past prices (or quantities, as appropriate) are known but only their own profit functions are known.

The findings are best represented in the recent book by Friedman and Hoggatt (1980) which describes the results of several oligopolistic markets under varying parametric and information conditions. The two models are compared: the joint maximum model and the Cournot equilibrium. The competitive equilibriums where price equals marginal cost are not examined. Of course, the Cournot equilibrium prices are above these prices.

If the markets are characterized by perfect information and symmetric profit functions, the joint maximum is a good predictor for markets with up to four sellers. For the market with six sellers, prices dropped substantially to the Cournot equilibrium or just above it. If symmetry is dropped or if perfect information is dropped,[4] the number of sellers becomes a very important treatment variable. In the duopoly markets, significant (but less than perfect) cooperation occurs but with an increase in the number of firms it vanishes almost completely and the Cournot model is very accurate by comparison. Friedman and Hoggatt conjecture what Stoecker convincingly demonstrates that experience

makes a difference. "New and inexperienced faces" can cause market prices to deteriorate.

Thus, for the posted price institution a pattern is emerging. The institution seems to foster higher prices in general. Furthermore, under appropriate basic economic conditions and market structures, it can foster collusion in the sense that the joint maximizing model is an accurate predictor of pricing patterns.

D. Advance Notification and Price Protection

The recent actions taken by the Federal Trade Commission[5] have drawn attention to the market institution in the antiknock compound industry.[6] Industrial practices assure customers of a thirty-day advance notice of price changes (increases). Prices are quoted in terms of delivered prices with the same price prevailing regardless of transportation costs. In addition, contracts typically include a "price protection" clause which guarantees (i) that the seller will sell to no one at a price less than the price quoted the buyer and (ii) the seller will meet any lower price in the market or release the buyer from the contract.

The industry structure is characterized by two large sellers of equal size (approximately 35 percent of the market each) and two small sellers of about equal size. A long-run declining demand (due to a reduction in lead use in gasoline) and existing excess capacity discourages entry. Eight large buyers account for about 60 percent of the sales and many very small buyers account for the rest.

Plott (1981) has explored markets with these properties. Each agent was assigned an office. Sellers were able to post prices by means of a digital electronic display system such that price announcements were made known immediately to all market agents. Orders were placed through

the telephone system. Price increases required advance notice and all transactions were made at advertised prices (the buyer protection clause which precludes discounts). The industrial structure was as described above with the market demand and supply functions as shown in Figure 3.

The major conclusion of this study is that these practices when combined with the industrial structure cause prices to be above those that would otherwise exist. Figure 8 gives average prices during each of seventeen trading periods. Market institutions were a simple telephone market during the first twelve periods. As can be seen, the prices begin to decay toward the competitive equilibrium. The practices were imposed for periods 13 through 16. As can be seen, prices jump immediately to near the Cournot equilibrium. When the practices were removed (periods 16 and 17) prices immediately fell. These data are representative of the pattern of findings from twenty-two experimental markets.

The theoretical explanation of this phenomenon has some support. Advance notice given sufficiently in advance of the deadline for advance notification provides a signal to other sellers. If the notice involves a price sufficiently far in the future, it induces no current business loss. Only a single price is involved so the signal is uncomplicated with minimal dimensions over which disagreement can occur. Other sellers know that if they do not increase prices before the deadline, the original firm will rescind the proposed price increase. Thus other sellers do not have the option of "underselling" and acquiring a larger market share. The Nash strategy for such firms is simply to match the proposed price if a uniform industry price at the higher level will increase the firm's profits and do nothing otherwise. On the downside, due to the homogenous nature of the product, if not the buyer's protection, price cuts will

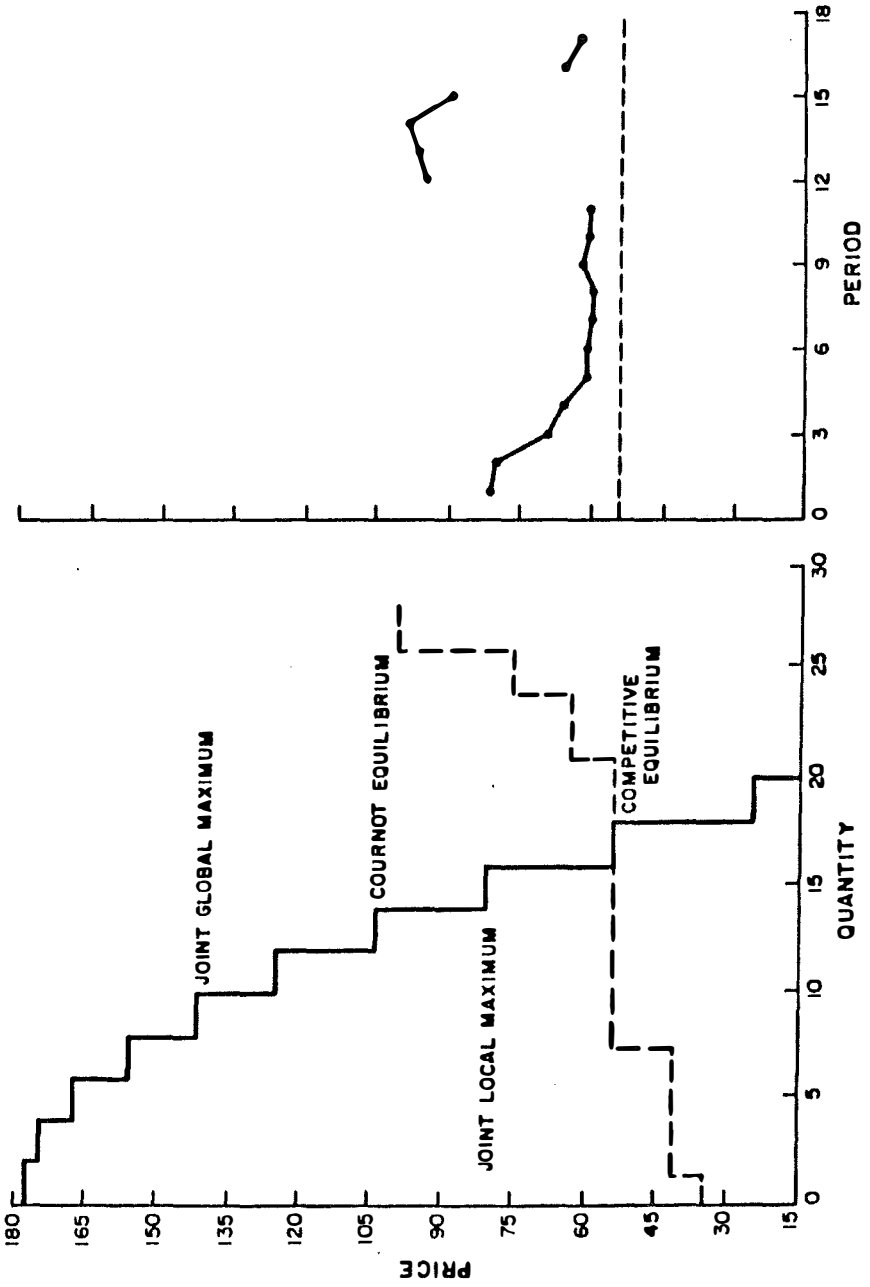


FIGURE 8

be matched, so the incentive to cut prices depends upon the anticipated share of demand increase due to lower price levels. This model predicts that prices will certainly be at Cournot levels if not higher.

These institutions seem to have an effect on buyers similar to the posted price institutions. Buyers do not anticipate discounts because the institutions prevent them. Furthermore, since any price concessions must be offered to all, buyers can see that price concessions can be costly to the seller and thus have less expectation of winning them. As a result, the buyers seem to have less "counterspeculation" than in, say, the telephone markets alone. Thus these institutions appear to remove one source of buyer pressure for reduced prices while at the same time easing the problem of price coordination for the seller and eliminating the advantages of price cuts.

EXTRAMARKET COMMUNICATION

Communication which facilitates price coordination could conceivably take many forms. Many industrial organization scholars feel that collusion is easy and takes little more than recognition of a harmony of interest. Others feel that collusion cannot be achieved without contracts, surveillance, and sanctions. In this section we will review forms of communication which can carry an offer of collusion. First discussed will be cases in which such signals must be conveyed within the context of the market itself. If agreements evolve, they must be facilitated in terms of actions without the aid of ordinary language. Following that the results of two studies, which were designed to study organized collusion, will be summarized.

A. Signals

Is it possible for natural competitors such as human sellers to form an alliance without the aid of language? Can such alliances occur in the absence of any signals, threats, etc. in the sense that the context itself suggests collusion? The best answer to this question appears in the data of Stoecker (1980). Fouraker and Siegel format, perfect-information, duopoly experiments[7] were conducted with experienced participants.[8] Out of fifty markets (lasting ten periods each) thirty-seven achieved a rather stable (end of period effects cause some ambiguity in interpretations) equilibrium at or near the joint maximum. Nineteen of the thirty-seven markets attained this coordinated equilibrium with no signals or "learning." It occurred with the first price choice with both competitors choosing the maximum and for the most part the systems stayed there. Thus, in this context, in which the harmony of interest could be clearly ascertained with no room for ambiguity or confusion, some duopolies needed no means of communicating intentions at all. For a subset (eighteen) of these fifty duopolies the joint maximum was not the individual maximum given equal prices. Of these, thirteen achieved stable equilibrium near the joint maximum and of the thirteen there were four which attained the equilibrium with the first move. Since these duopolists had twenty prices to choose from, it would be difficult to ascribe these coordinated actions to chance.

Within other industrial structures and market institutions thus far explored, the existence of any one of (i) a harmony of interest, (ii) a recognized attempt to collude, or (iii) even a "focal point" is not a sufficient condition for collusion. Market signals occur constantly in oral double auctions. After a contract, when the market is open for bids

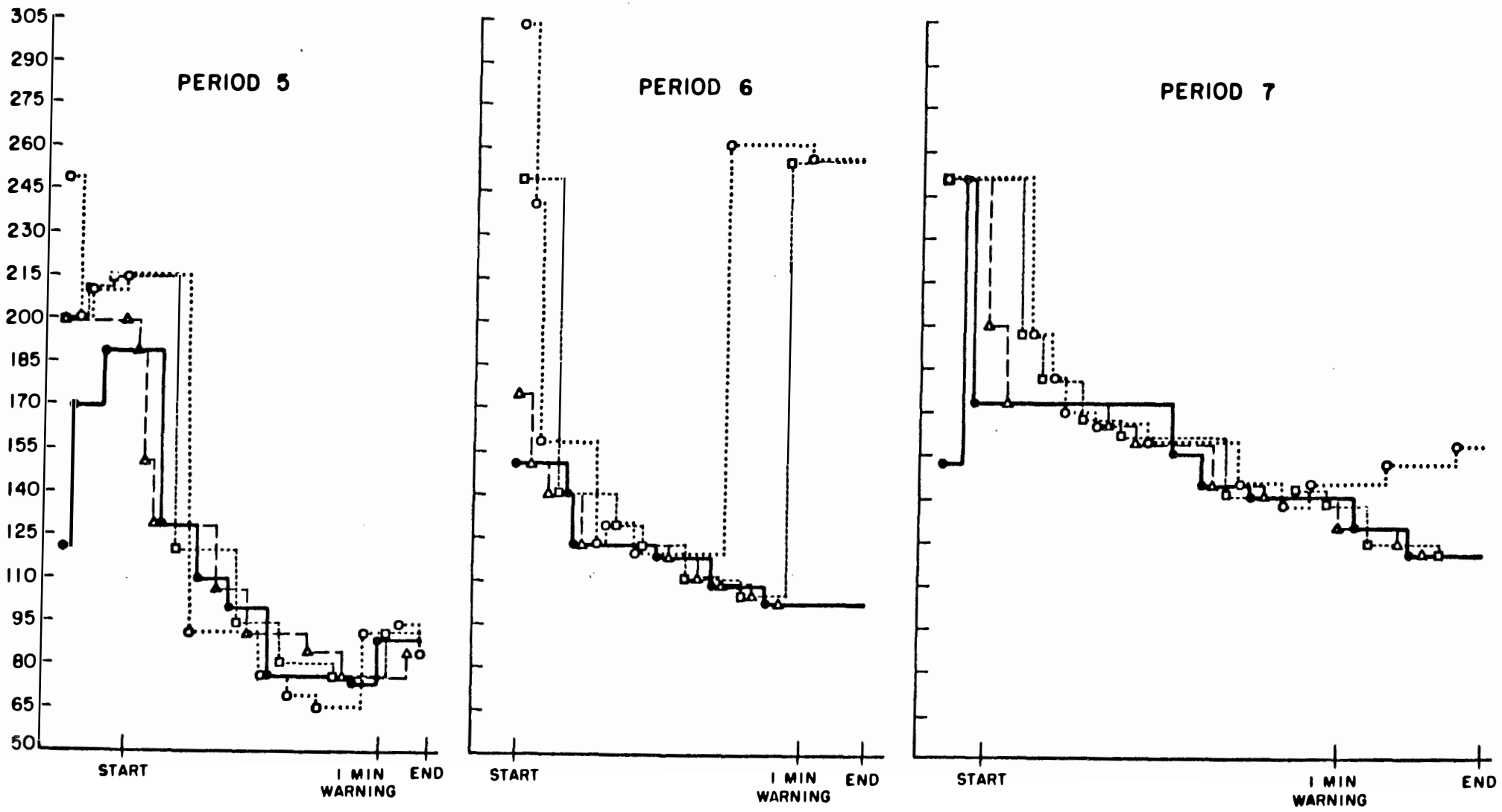
or offers, the bidding will sometimes start with a clearly unacceptable bid (e.g., a 1 cent bid or something far below any previously accepted price) and it will often be followed by similar bids from other buyers who are indicating a willingness to keep prices low. When this happens, sellers are not passive. Such bids may be answered by an equally ridiculous set of offers from sellers indicating that the other side can play that game too. However, even if there is no answer, the sellers do not sell. They simply wait (counterspeculate) as the competition between buyers slowly works the bids into the previously accepted range. Signals such as these never seem to work in the double auction institution or if they do the effectiveness is not immediately obvious.

Both the Plott and Uhl (1981) and the Isaac and Plott (1981b) as well as the Smith and Williams (1981) experiments are interesting in this resepct. The former involved a set of middlemen who bought and sold in spatially separated markets. The latter two papers involve a price ceiling (floor) slightly above (below) the equilibrium. The harmony of interest in the first study and the "focal points" in the second two studies were obvious, yet the markets converged to near the competitive equilibrium with no signs of implicit collusion or conscious parallelism of actions. In these studies with four sellers and the oral auction institution there was no sign of the coordination possibilities demonstrated by Stoecker.

Hoggatt, Friedman, and Gill (1976) and Friedman and Hoggatt (1980) provide the only attempts to model the signaling phenomenon. In part signals are viewed as attention getting devices. Most of the work is an attempt to identify a signal as something distinct buried in the masses of data of the ordinary searching and competing price decisions.

Within the posted price institution high or low prices have an immediate effect on profits so, as one might expect, signals occur rarely relative to other decisions. Signals are identified as a type of "pulse" in which an abrupt change of behavior occurs for a brief period (a sudden large price increase or decrease) followed by a return to the original levels. Friedman and Hoggatt have attempted to develop models which will relate this activity to overall price changes and/or price levels. As of this writing they have a reasonable characterization of the phenomenon but feel it happens so infrequently in their data that the implications cannot be ascertained.

Data generated in a "semi posted price" market provide some insights into how signaling might occur and be useful. The institution is a market with advertising (by an electronic digital display system) with a stipulation that all sales are at advertised prices. A "price war" has reached a low point in period 5 (Figure 9). Notice the existence of advertising before period 5 opens. Prices cave soon after the market opens and continue downward during the period with almost all transactions (not shown) made at the low prices. Buyers seemed to be counterspeculating until prices fell. The period ends but signaling begins with very high prices being advertised when it costs nothing to do so before period 6 begins. The period starts and price cutting begins immediately but the sellers who signaled high prices meet price cuts this time rather than cutting below. As a result the speed of price decay is reduced and in the end transactions occur at somewhat increased prices. Notice that the two signaling individuals have their prices high before the period ends (having limited capacity, they have sold out and can now signal with little cost incurred).


305
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65
50
PERIOD 5
START
1 MIN WARNING
END
PERIOD 6
START
1 MIN WARNING
END
PERIOD 7
START
1 MIN WARNING
END
●, △ large sellers
○, □ small sellers

FIGURE 9

Prior to period 7 all advertised prices are at a high level and the decay is less. This process continues as prices creep upward for several periods. Of course these data are not demonstrations that price signals can affect prices but they are certainly suggestive of how it might happen. They are also typical of a general tendency for signals to occur through channels and at times when such communication is not costly.

B. Auction Markets

The effectiveness of preperiod discussions by sellers (buyers) on prices in a double auction market was explored by Isaac and Plott (1981a). The four sellers (buyers) were allowed to talk freely between periods while the buyers (sellers) left the room to get the next period's demand (cost) functions. No side payments or profit sharing discussions were allowed.

The study asked the following questions. Do traders discuss collusion when given the opportunity? Can the traders formulate some sort of agreement? Once formulated, do they stick to it? Can the consequences of the conspiracy be detected in the industrial conduct?

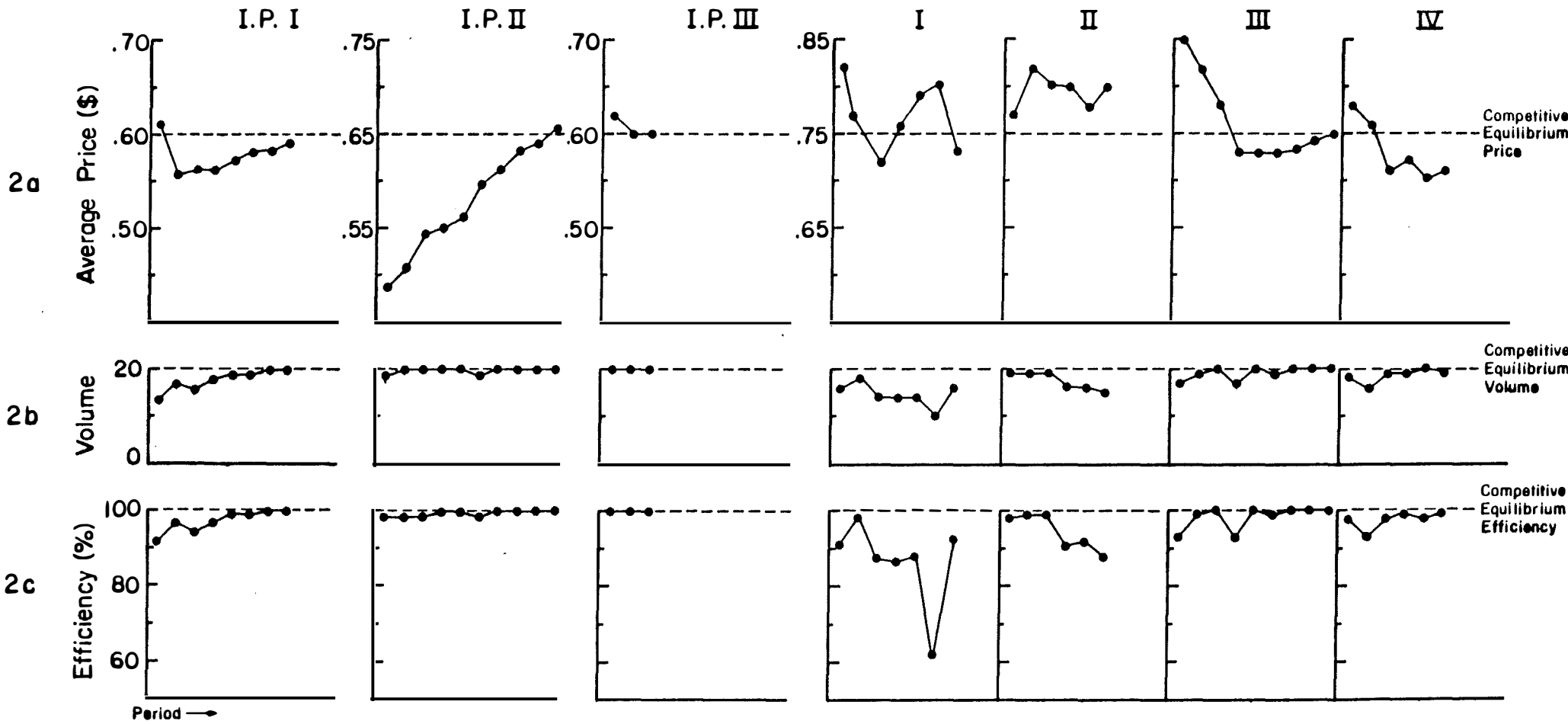
The answer to the first two questions is yes. The answers to the second two are not without qualifications. Data in Figure 10 provide a comparison with the oral double auction when no collusion is present (the first three experiments), with those in which there is a seller's conspiracy (the fourth and fifth) and a buyer's conspiracy (the sixth and seventh). The top charts are the average prices each period. The middle charts are the per period volumes and the bottom charts are the efficiencies.

In order to see the effects, it is important to notice the near monotone convergence of all three measures in the first three nonconspiratorial markets. Prices, volume, and efficiency, all three move monotonically to the competitive equilibrium levels. This does not happen in the conspiracy markets. In each of the four experiments with conspiracy, with the possible exception of experiment III, at least one of these measures exhibits some erratic behavior in the sense of a movement away from equilibrium. In this sense the conspiracy might be detectable from market data, but experiment III indicates the difficulty. Notice in experiment III there is a strong tendency toward the competitive levels even though there is an active conspiracy.

Figure 11 will help explain what is happening. Shown there is the sequence of bids, offers, and contracts from experiment III. This experiment involved the dramatic reduction in prices in period 4 as a result of a successful buyer's conspiracy.

> Some general discussion began after period 3. Note that, unlike period 3, the buyers in period 4 did not rush to accept high seller offers. In period 3, five of the first six trades were offers between 83 cents and 88 cents. In period 4, no offers were accepted until they reached 73 cents. In period 5, the tenth bid was at 72 cents. Between periods 5 and 6 the sellers agreed to try to hold the price at 71 cents. In period 6, the first twenty-seven bids were all either at 70 cents or 71 cents, with several intervening offers at 72 cents ignored. The twenty-eighth bid broke the agreement, and there were ten immediate trades at 72 cents.

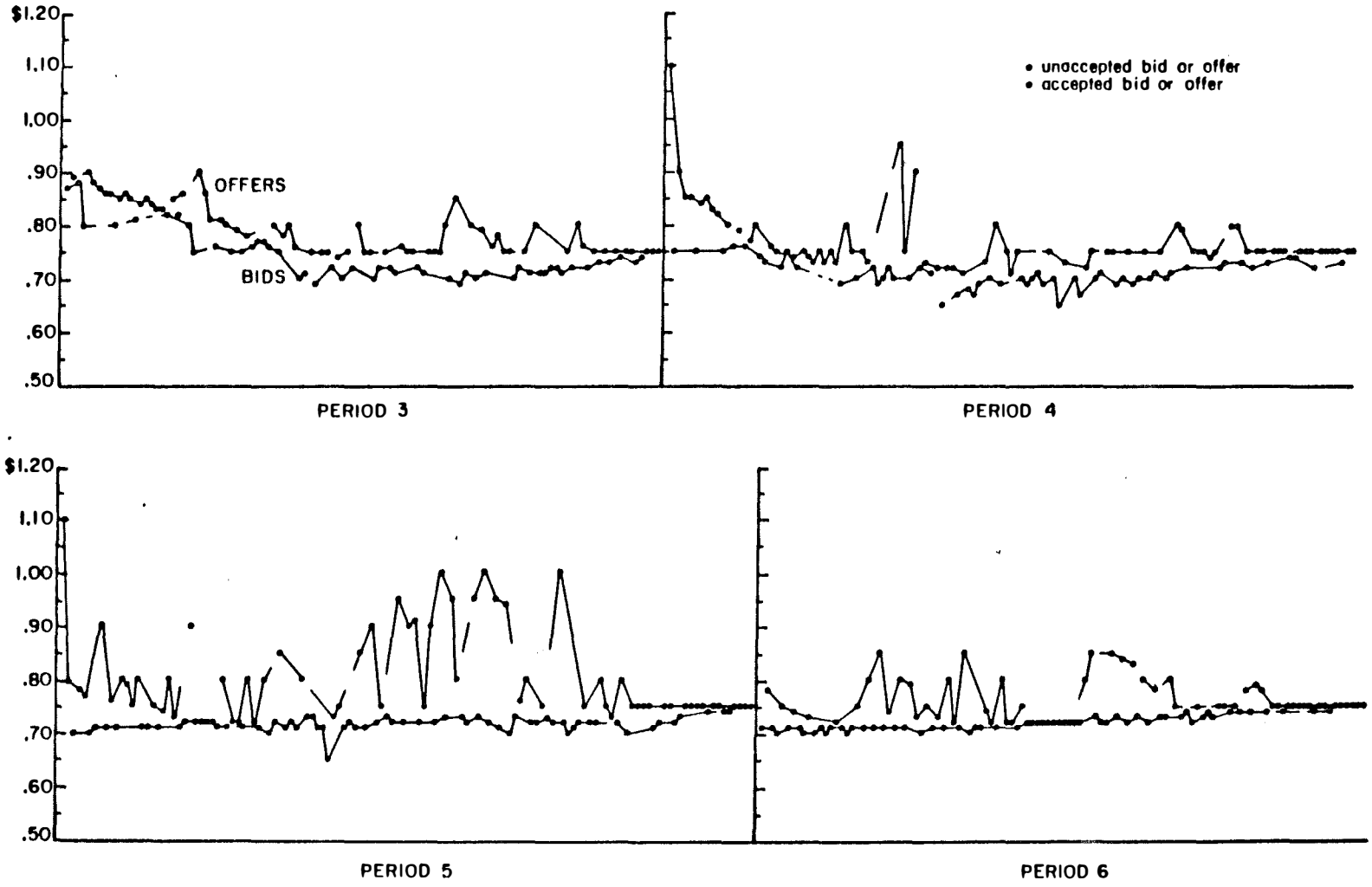
Of particular interest in this context are the high offers in period 5. These are interpreted as signals by sellers as an attempt to get other sellers to hold out. Frequently, however, they are made by sellers who have already sold and now have only high cost units which they do not expect to sell. The cost of signaling to them is low. Nevertheless, the fact that the nonconspirators are not simply passive is obvious.



AVERAGE PRICE, VOLUME, AND EFFICIENCY PER PERIOD

FIGURE 10

Source: R. Mark Isaac and Plott, Charles R. "The Opportunity for Conspiracy in Restraint of Trade: An Experimental Study." Journal of Economic Behavior and Organization 2, forthcoming.



EXPERIMENT III PERIODS 3,4,5 AND 6
ALL BIDS AND OFFERS

FIGURE II

Source: R. Mark Isaac and Plott, Charles R. "The Opportunity for Conspiracy in Restraint of Trade: An Experimental Study." Journal of Economic Behavior and Organization 2, forthcoming.

The difficulty these conspirators have in substantially affecting market conduct seems to be related to the market institutional environment. As the Smith results reviewed above demonstrate, even a perfect conspiracy (monopoly) has difficulty in the double auction. Add this property of auction markets to the fact that duopolists can have difficulty in achieving coordination even under the most favorable conditions as was discussed above. Perhaps then it is not surprising that the industrial structure used in the Isaac and Plott experiments (four buyers and four sellers) would make successful conspiracy difficult.

C. Posted Prices

If the market institutions are the posted price and the industrial structure is duopoly, a completely different picture emerges. Friedman (1967, 1970) studied posted prices of duopolies with asymmetric payoff functions. Perfect information existed in the sense that each competitor knew all previous price choices and payoffs (up to a scalar transformation on occasion). Competitors were allowed to transmit two written messages before privately making a price decision. These messages were made in sequence with the same individual initiating contact for each of up to twenty-five periods (although most were from six to fourteen). In his data collusive agreements were attained in over 75 percent of all decisions made and of the collusive agreements 75 percent were Pareto optimal relative to the pair (no side payments were allowed). The ability to make such agreements increases with experience. Once a collusive agreement has been attained and successfully implemented, the probability of another successful agreement is .96.

Extramarket communication does have implications for market conduct. Perhaps this is no surprise for those who have observed industry for years but these studies demonstrate the truth of the proposition for those who have not had the benefit of such observation or believe that the "competitive drive to defect" is so strong that collusion is impossible. However, the implications in terms of conduct cannot be divorced from both industrial structure and the market institutional environment.

CLOSING REMARKS

Experimental studies demonstrate clearly that market institutions and practices can influence market performance. Variables traditionally classified as aspects of industrial structure are also of demonstrable importance. Furthermore, rather standard mathematical models are able to capture much of what can be observed behaviorally.

Three models do well: the competitive equilibrium, the Cournot model, and the monopoly (joint maximization) model. Some tendency exists for the error of the model to be sensitive to structural and institutional variables (e.g., posted prices tend to be higher than prices under oral double auctions) but generally speaking, when a model applies, it does so with reasonable accuracy.

Interestingly enough, while experimental studies demonstrate that it is possible to model economic processes, they have also uncovered a problem in determining the conditions under which a model will be applicable. There is an interaction between variables which has not been fully explained. It is not the case that competitors are capable of collusive activity when merely recognizing a harmony of interests.

It is also not the case that competitors cannot collude in the absence of direct communication and the enforcement of agreements. Competitors seem to be willing to collude (so the rivalistic hypotheses[9] advanced in the early experimental studies can be safely dropped) but some industrial structures and market institutions make it easy while others make it almost impossible (in the sense that successful collusion has never been observed). Even a monopolist has difficulty within certain market institutions. Existing theory does not tell us exactly why this occurs, but the data suggest that one key is the behavior of the buyers. The data also suggest that market performance is very fragile with respect to these underlying variables and that "slight" changes (from four to two firms, or from price posting to some other institution) can switch a market from "competitive" to "collusive" or vice versa.

One major question which experimental studies have not addressed is the evolution of the market institutions themselves. What type of market institutional environment might one expect for a given industrial structure? The data suggest the nonneutrality of the marketing practices so one might expect that self-interested individuals who realize the relationships and have an opportunity to affect market institutions would do so. To the extent that market institutions are part of market conduct, industrial organization economists have a clear interest in this question. Perhaps the reason that this issue has not been addressed reflects the fact that the independent influence of institutions is only now being realized. No doubt this void will be filled as theory is developed which will suggest what one should look for in an experimental environment.

The studies reviewed above were all designed and executed to answer reasonably specific questions generally related to basic science. Sometimes applied scientists dismiss the experimental results and methods as being irrelevant and inapplicable. In the remaining paragraphs four of the most common sources of skepticism will be discussed.

The first argument is a claim that "real" businessmen do not behave as do the subjects in these experiments. Stated like this the argument is not a criticism of experimental methods, it is a hypothesis about behavior in different subject pools and is thus a call for more experiments (with businessmen subjects). Similarly, arguments that the amounts involved were too little (or too much) are simply demands for more experiments. The fact of the matter is, however, that a variety of subjects and payment levels have been used. The Hong and Plott (1981) study, for example, used employed adults. To date no subject pool differences have been reported.

The next three arguments derive from the fact that naturally occurring phenomena are inherently more complex than are laboratory processes. The first argument is that the laboratory environment is artificial. Exactly why is not articulated but with this argument the word is used many times and preferably loudly. It probably results from a gestalt view that there are so many important variables that they cannot be enumerated and that they interact in ways that are necessarily precluded in the laboratory.

This argument, notice, is not an argument against experimental methods in economics, it is an argument against experimental methods in general. The physical scientists must deal with it and so must the economists. Since the assertion cannot be falsified, the only answer

lies in experimental work that has been helpful in generating successful models and points of view regarding more complex processes. As applied researchers find the data from experiments useful in shaping their own hypotheses and beliefs, this argument becomes less important.

The second argument is more specific in that it notes that naturally occurring processes do not occur in isolation. Industries are embedded in a larger social context. Businessmen have social relationships and friendships. They also know that their decisions while with one firm may affect their possibilities for changing firms.

This argument suggests that behavior in very complex environments may follow different laws than those which govern behavior in relatively simple situations. This is an excellent reason for being careful in any attempt to extrapolate behavior from a laboratory to a complex industry. Notice, however, that it is not an argument against experimental methods. It is an argument for a particular type of experiment--one in which the complexity of the experimental environment is gradually increased similar to those of a given industry. If complications destroy the applicability of models, it might be possible to identify the precise complications which cause the problem and adjust the model accordingly. In a sense this program of increasing complexity is exactly how experiments are proceeding.

The final criticism also relies on the complexity of naturally occurring processes. How is one to know if the elasticity of demand and costs used in an experiment or if the particular market institution are those of the industry? If the results of the laboratory experiments are to be applied, shouldn't these be "right"? The answer to these

types of criticisms are still more experiments under varying parameters. With a wide range of parameters explored, the question collapses into a judgment about parameters and not the experimental methods.

All of these arguments should make one cautious about extrapolating results generated from laboratory processes to naturally occurring processes. This type of extension must be dealt with artfully in the physical sciences as well as in economics. It is the most difficult task that any researcher faces. Experiments are simply an additional source of data and experience that one adds to other sources in making judgments about how the world works.

An easier task involves a somewhat negative approach placing the burden of proof on those who advocate theories. General theories apply in special cases. They should therefore be expected to work in the simple laboratory environments and if they do not or if a competing theory works better, the burden of proof is on the advocate to tell us exactly why we should not judge him to be wrong. By adopting this point of view, researchers can use data from laboratory economics to reduce the size of the set of competing ideas.

FOOTNOTES

1. Experimental Results

For those who are unfamiliar with laboratory experimental methods, a brief description should help. The basic tool is the theory of induced preference (Smith, 1976). Each individual buyer, i, is given a function, $R_i(x_i)$ indicating the amount of money s(he) may collect from the experimenter expressed aa a function of the number of units, x_i, of an abstract commodity s(he) purchased during a period. The profits for the individual are the differences between the redemption values and the purchase prices. (In moat studies a commission of 10 cents or so is paid in addition to the redemption values. However, the maximum price an individual can pay is declared by the experimenter to be $\frac{\partial R(x_i)}{\partial x_i}$.) Thus, if an individual prefers more money to less and if the only value derived from the abstract commodity is from its resale value, the function $\frac{\partial R^i(x_i)}{\partial x_i}$ measures the limit prices of individual i.

Cost functions are induced similarly for sellers. That is, each seller, i, is given a function $C^i(x_i)$ indicating the cost s(he) will incur with sales of x_i. Profits are the differences between revenues and costs. Thus, according to the competitive model $\frac{\partial C(x_i)}{\partial x_i}$ is the (inverse) supply function for i.

If the laws of economics apply in general, then they should apply to this simple market as well. The people are real. The incentives are real. The abstract commodity now has value by virtue of the fact that payments can be substantial and by virtue of the theory of derived demand. The commodity is scarce. The fact that the market is simple by comparison to its natural counterparts does not mean that the behavior is simple. Nevertheless the simplicity should reinforce our expectation

that models and theories which are being applied in those complicated cores should work well indeed when applied to the simple ones.

One need only inquire now about models which accurately predict the observed conduct. All prices and incomes are observable. Efficiency can be measured as the standard consumer's plus producer's surplus. Efficiency in this sense is 100 percent if and only if participants maximize total earnings (extract the maximum possible from the experimenter). Thus, some of the major economic dimensions of industrial performance can be assessed.

See Research in Experimental Economics, vol. 2, edited by Vernon L. Smith, Greenwich, Conn.: JAI Press, forthcoming, which contains several papers on sealed bid processes.

This study involved a slight variant of the oral double auction. Bids and offers were left open until accepted or changed. Thus the market institutions were similar to a double oral auction with limit orders and an open book.

Information in Dolbear, et al. did not have a measurable effect. Subsequent experiments suggest that the payoffa used in this experiment were so small (5 cents difference in profits between Cournot equilibrium and monopoly) that the influence of any variables would be hard to detect. Nevertheless, the data tend to be very close and just above the Cournot equilibrium and the qualitative influence of other variables is consistent with those of later studies.

5. The Federal Trade Commission complaint against Ethyl, DuPont, PPG, and Nalco Chemical Company (Ethyl Corporation, et al. Docket No. 9128).

6. The product is added to gasoline by refiners to reduce knock and raise gasoline octane rating.

7. The industrial organization analog is a duopoly with a homogenous product, posted price markets with simulated buyers, and publicly known profits and prices.

8. The subjects had participated in at least one other duopoly experiment.

9. This hypothesis maintained that competitors will attempt to maximize relative profits thereby transforming the market into a zero sum game.

REFERENCES

Coppinger, V. M.; Smith, V. L.; and Titus, J.A. (1980) "Incentives and Behavior in English, Dutch and Sealed-Bid Auctions." Economic Inquiry 18 (January):1-24.

Dolbear, F. T.; Lave, L. B.; Bowman, G.; Lieberman, A.; Prescott, E. C.; Rueter, F.; and Sherman, R. (1968) "Collusion in Oligopoly: An Experiment on the Effect of Numbers and Information." Quarterly Journal of Economics 82 (May):240-259. Reprinted in the Journal of Reprints for Antitrust Law and Economics 10, no. 1 (1980):415-36.

Forsythe, Robert; Palfrey, Thomas R.; and Plott, Charles R. (1981) "Asset Valuation in an Experimental Market." Econometrica (forthcoming).

Fouraker, L. E. and Siegel, S. (1963) Bargaining Behavior. New York: McGraw-Hill.

Friedman, James W. (1963) "Individual Behavior in Oligopolistic Markets: An Experimental Study." Yale Economic Essays, vol. 3, pp. 359-417.

_____. (1967) "An Experimental Study of Cooperative Duopoly." Econometrica 35 (October):399-415.

_____. (1969) "On Experimental Research in Oligopoly." Review of Economic Studies 36 (October):399-415.

_____. (1970) "Equal Profits as a Fair Division." In Beiträge zur Experimentellen Wirtschaftsforschung, vol. II, edited by Heinz Sauermann, pp. 19-32. Tübingen, Germany: J. C. B. Mohr.

_____ and Hoggatt, Austin C. (1980) An Experiment in Noncooperative Oligopoly. Supplement 1 to Research in Experimental Economics, vol. 1. Greenwich, Connecticut: JAI Press.

Hoffman, Elizabeth, and Plott, Charles R. (1981) "The Effect of Intertemporal Speculation on the Outcomes in Seller Posted Offer Auction Markets." Quarterly Journal of Economics 96, (May):223-41.

Hoggatt, Austin, C. (1959) "An Experimental Business Game." Behavioral Science 4:192-203.

_____. (1967) "Measuring Behavior in Quantity Variation Duopoly Games." Behavioral Science 12:109-121.

_____; Friedman, James W.; Gill, S. (1976) "Price Signaling in Experimental Oligopoly." American Economic Review 66 (May): 261-266.

Hong, James T. and Plott, Charles R. (1981) "Implications of Rate Filing for Domestic Dry Bulk Transportation on Inland Waters: An Experimental Approach." Bell Journal of Economics (forthcoming).

Isaac, R. Mark and Plott, Charles R. (1981a) "The Opportunity for Conspiracy in Restraint of Trade: An Experimental Study." Journal of Economic Behavior and Organization (forthcoming).

_____ and _____ (1981b) "Price Controls and the Behavior of Auction Markets: An Experimental Examination." American Economic Review (forthcoming).

Miller, Ross M.; Plott, Charles R.; and Smith, Vernon L. (1977) "Intertemporal Competitive Equilibrium: An Empirical Study of Speculation." Quarterly Journal of Economics 91 (November):599-624.

Murphy, J. L. (1966) "Effects of the Threat of Losses on Duopoly Bargaining." Quarterly Journal of Economics 80 (May):296-313.

Nelson, Forrest D. (1980) "A Note on 'Experimental Auction Markets and the Walrasian Hypothesis.'" Social Science Working Paper no. 307. California Institute of Technology, Pasadena.

Plott, Charles R. (1981) "Price Protection Policies and Market Performance." Mimeograph, California Institute of Technology.

_____, and Smith, Vernon L. (1978) "An Experimental Examination of Two Exchange Institutions." Review of Economic Studies 45 (February):133-153.

_____, and Sunder, Shyam. (1980) "Efficiency of Experimental Security Markets with Insider Information: An Application of Rational Expectations Models." Social Science Working Paper no. 331. California Institute of Technology, Pasadena.

_____, and Uhl, Jonathan. (1981) "Competitive Equilibrium with Middlemen: An Empirical Study." Southern Economic Journal 47 (April):1063-71.

Scherer, Frederic M. (1971) Industrial Market Structure and Economic Performance. Chicago: Rand McNally.

Smith, Vernon L. (1962) "An Experimental Study of Competitive Market Behavior." Journal of Political Economy 70 (April):111-137.

_____. (1964) "Effect of Market Organization on Competitive Equilibrium." Quarterly Journal of Economics 78 (May):181-201.

_____. (1965) "Experimental Auction Markets and the Walrasian Hypothesis." Journal of Political Economy 73 (August):387-393.

_____. (1976a) "Bidding and Auctioning Institutions: Experimental Results." In Bidding and Auctioning for Procurement and Allocation, edited by Y. Amihud. New York: New York University Press.

_____. (1976b) "Experimental Economics: Induced Value Theory." American Economic Review 66 (May):273-279.

_____. (1981) "An Empirical Study of Decentralized Institutions of Monopoly Restraint." In Essays in Contemporary Fields of Economics in Honor of E. T. Weiler, edited by George Horwich and James Quirk. West Lafayette, Ind.: Purdue University Press (forthcoming).

_____, ed. (forthcoming) Research in Experimental Economics, vol. 2 Greenwich, Conn.: JAI Press.

_____, and Williams, Arlington W. (1981) "On Nonbinding Price Controls in a Competitive Market." American Economic Review (forthcoming).

Stoecker, Rolf. (1980) Experimentalle Untersuchung des Entscheidungsverhaltens im Bertrand-Oligopol. Bielefeld: Pfeffer.

Williams, Arlington W. (1979) "Intertemporal Competitive Equilibrium: On Further Experimental Results." In Research in Experimental Economics, vol. 1, edited by Vernon L. Smith. Greenwich, Conn.: JAI Press.

_____. (1980) "Computerized Double-Auction Markets: Some Initial Experimental Results." Journal of Business 53:235-258.

Williams, Fred (1973) "The Effect of Market Organization on Competitive Equilibrium: The Multiunit Case." Review of Economic Studies 40 (January):97-113.